Remme

Gift of
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John

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Notes
on
Natural Philosophy
taken from
Mr Playfair's Class
During
The Winter Session
at
Edinburgh
Years 1807 & 1808.

Natural Philosophy

Without entering into the history of
Natural Philosophy, we shall at once
commence with an explanation of
that Science, & proceed on in regular
progression with the Lectures
as given during a Winter Session.
The meaning of Natural Philosophy
is to investigate the causes, that result
from the Phenomena of Nature.
1st Natural things are all bodies
& the assemblage of them is called
the Universe.

2nd The word Phenomena is an

appearance or whatever is perceived by our
 senses. Thus the fall of a Stone or
 the report of a Gun are Phenomena.
 All Phenomena depends on
 the properties peculiar to dif-
 ferent bodies. it is the business
 of Natural Philosophy to ex-
 amine the different Properties
 of bodies. & from thence to infer
 useful Deductions.

The general Axioms of Philosophy

1st. Nothing has no properties, hence

2nd no substance can be produced from

nothing—

3rd Matter cannot be annihilated —

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4 Every effect is produced by a cause ~~that~~[&]
is proportionate to it —

Matter

The matter or substance of bodies that
we see, feel, taste, or in short that
effect our Senses, become known
to us merely by its properties

We know, that the Sun, exists
because we feel its heat; — Now
it is evident the Sun must con-
sist of something. That something
is called matter, yet we cannot
determine the particles or what

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They consist of —

Space

may be said to be that Univer-
sal & unlimited expanse in
which all bodies are contained;
And that part of Space oc-
cupied by a body is called the
space of that body. This is dis-
tinguished into Absolute &
Relative Space.

Absolute Space is that
which is referred to nothing
& remains always similar &
immovable —

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Relative Space is the same
with the Absolute in magni-
tude & figure but different
in situation. Suppose that
a hollow Ball stood immove-
ble in the Universe, the space
contained within its cavity would
be called Absolute Space, but
if the Ball be in motion the
Space would be called Relative
Space. Place refers to bodies
the same as Absolute & Relative
the former being immovable & the
latter movable, whereas the latter

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refers to other bodies. If a man be seated¹¹
in a part of a ship, & as the ship sails
along, he is said to remain in the
same place Relatively to the
parts of the ship; yet he is con-
tinually changing his Absolute
place.

Rest

is the permanency of any
body in the same place, it is called
Absolute and Relative rest as
the place which the body occu-
pies is either the one or the o-
ther.

on the contrary is a continued change of place. And it is called Absolute and Relative Motion according as the change of situation is made either the one or the other. Example

If a Boat be immovable in the Universe, a Man sitting in a part of it, would be said to be absolutely at rest. But if the Boat be in motion while the Man is sitting, then the Man will be at Rest Relatively to the parts

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of the Boat, though he is absolutely
in motion.

The word Matter has no determinate figure, whereas the word body indicates some separate quantity of Matter.

Time

properly speaking, is incapable of Definition. If the only difference with Absolute & Relative

Time. The former flows equally but does not refer to the motion of bodies. The latter is that portion of Time during which a certain

movement is performed —

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The properties of a thing are those
qualities & operations, which be-
long to ~~the~~ thing, & by which it is
distinguished from other things
that do not possess the same pro-
perties —

The Hardness of a body is that
degree of resistance which the body
offers to any power that may be
applied to separate its parts. Where-
as Fluidity is the want of that
resistance, But we are neither
any perfectly Fluid or perfectly

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Cause & Effect are Relative terms
 the first being produce by the
 second. & that Relating to the first

Of the common properties of
 Matter

Extension 1 &

Divisibility 2

Impenetrability 3^d

Mobility 4 & 1 Principle

is Inertia 5th

& Gravity 6th

1st Extension of a body is the quan-
 tity of Space which a body occu-
 pies; It is called the ^{magnitude} ~~surface~~

of a body. A Body has length^{2d}
breadth & thickness.

The outside of a body is called the sur-
face of a body & has only two dimensions
viz length & Breadth.

We commonly imagine a surface
but a surface can only exist but
with a body.

Divisibility is the proper to it
being divisible into parts ad infinitum.

See prop^{1st}. Let AB be the proposed line
through the point A & B draw the

straight lines parallel to one another

take any point c in the line EF draw

lines to any part of EF. then as the line
EF can be produced ad infinitum the
divisibility must be the same.

Impenetrability is that property by
which one body excludes another
body from occupying its own place.

Mobility X

is that property whereby a body
is capable of being moved from one place to
another. All bodies are capable of being
moved if a sufficient power be applied. A body
once put in motion, has no power to stop itself
nor can it cease in its action upon by some external
cause. Also a body at rest has no power to put itself
in motion unless impelled by some external cause &
will move with a certain velocity according to
its impulse.

Attraction is that property whereby one

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body, endeavour to get near another, This is the
 property, whereby bodies tend fall towards the
 Earth & is called Gravity

Motion

Mobility, Inertia & Gravity are the
 foundation of the doctrines of Motion
 2 kinds of Forces viz impulsive & accu-
 rative forces

1 Laws of Motion

1st Every body will continue to
 move in a straight line if not
 compelled to change that state by
 force impressed

Allowing that a body moves in a straight
 let AC be the straight line, make the

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angle $DBC = CBE$. then we say as there
is no reason why the body should move
in the line BD , any more than in
the line BE which makes an an-
gle equal to it, the body being
acted upon one force only and
that in the line AB consequent-
ly the body must move in the
line BC —

From this Proposition we may
infer that if a Stone be thrown
horizontally it would proceed
to move uniformly, were it
not drawn down by the force
of Gravity. This subject will

however be more fully described
however, in treating on the sub-
ject of Parabolas —

2nd The change of motion is at
ways in proportion to force in
press'd — it is to prove that the
body AB will move as fast if the
equal forces CA & AD be impressed

See Prop. page 28 by this, in the same

manner it would describe the

Diagram of a Parabolic System

see fig 2nd Page 28th —

3rd Action and Reaction are at
ways equal & contrary to each
other —

Examp. — If a man pull a

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Power attached to a body. The resi-
stance will be equal with the
force acted upon. & the body
will tend equally to pull
the Man towards it.

If the Mans power be not
greater than the resistance
he will not be able to move
the Body.

In equal Times the Velocities
are as the Spaces: But if the
Times are unequal. Then the
Velocities are as the Spaces di-
vid. by the Times respectively.
Let a Body pass over so Fast

in 2 min^{ts}. B 3 Ft 4 min^{ts}

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$A:B \frac{10}{2} : \frac{8}{4}$ Body 1 = 5 - 4B = 1 dividing

the Space by the Time

The Space is as the Velocity multiplied
by the Time or ($S :: V \times T$)

again ($T :: \frac{S}{V}$)

$M :: V \times Q$

($Q :: \frac{M}{V}$)

It will here be necessary to explain

to illustrate the doctrines of

Motion by experiment.

Experiment

The annexed fig^{re} is a Machine

having two Pulleys moveable

in Slides on of the Right Angle

illustrated by weights

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1st

2nd

3rd

1st 35

Page 34th — another Proposition of
forces compressed

Page 34th Proposition —

$$AB^2 + BC^2 = AC^2$$

$$S = a^2 + b^2$$

$$S = \sqrt{a^2 + b^2}$$

2nd

Prop —

Page 34 —

Euclid II. 12 Prop. — 3rd

$$AD = AB^2 + BD^2 + 2AB \cdot BP$$

Given th $S^2 = a^2 + b^2 + 2a \times BP$

Two constants $R : \sin BDP :: DB : BP$

for ~~to find their directions~~

to find their resultant force

$$1 : \cos \beta :: b : BP = b \cos \beta$$

$$S^2 = a^2 + b^2 + 2a \times b \cos \beta$$

$$S = \sqrt{a^2 + b^2 + 2ab \cos \beta}$$

The force A is the resultant force of all force AB, AC, AD AE

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Rule for Drawing the
Diagonal of a Rectangle
Humboldt's Geom. 1st Page 36

Machine
Composition
of
Forces

If 3 forces act upon a body, re-
presented by 3 sides of a Trian-
gle the body will remain
at rest. See fig 2nd Page 36
c the force from A to B

from B to B, C to D

then by completing the Paralle-
logram the Prop may be proved

Propth figth

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The force AE is the resultant
of all the forces AB, AC, AD, AE .

Having a number of forces acting
in different directions to find
the resultant force —

Recallaneous Prop - fig 2nd

Prop.

If any number of bodies fall in one
plane, act upon a body & at the point of
~~intersection~~ intersection, a line be drawn & let the angle
 B, B' & if we add the 2 Equations + & to the $\cos B + F$
 $\cos B''$ & or $F \cdot \sin B + F' \sin B' + F'' \cos B'' = 0$

$AL + AN + AR = 0$ - opposite directions

$AB + AS = AQ + AP$

$AL + AN + AR = 0$

$1: \cos B :: F: AL$

$F \cos B = AL$

$1: \sin B :: F: AS :: F: \sin B$

$F \cos B + F' \cos B' + F'' \cos B''$

3rd Law of Motion. 41

The action & reaction of bodies
are equal & contrary to each other

Prop. fig 1st Page 40

Ax into its velocity

Bx into its motion

Bodies that strike each other
1st A body is perfectly hard which
receives no impression after the
stroke

2nd An Elastic Body is that pro-
perty by which it regains its
former figure after the stroke

Definⁿ. All bodies are in some degree L3

Elastic. but we do not know perfection in either exists —

Elastic bodies are said to be perfectly elastic, when if struck against a like elastic body it rebounds back with a velocity equal to its impulse. or when after the blow it regains its former figure. otherwise it is called imperfectly elastic. When two bodies meet one another whatever momentum is lost by the one, must be acquired by the other again. if one of the bodies be at rest

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then as the momentum is nothing & 5
their joint momentums will be equal
to the momentum of the other body
before meeting. If Bodies move towards
each other. Their momentum after
meeting will be equal to the difference
of their former momentums, & if
their momentums are equal their
difference is nothing: hence the
bodies will remain motionless af-
ter meeting. I suppose the ~~the~~ ^{the} ~~the~~ ^{the}
weights & velocities of the bodies be
known. It is required to find
their velocities after meeting

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Let c . be their common centre of
 Gravity. & this place of meeting
 make $DE = DC$ then DE will show
 the velocity of the bodies after
 meeting, for since it has been
 proved that the common centre
 of gravity of the 2 bodies is not
 altered after meeting the velocity
 of their common centre of Gravity
 must be equal to its velocity
 before meeting that is $DE = CD$

See the annexed figure

Page 46 -

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Prop. see Page 48 fig 1st 49

$$\text{Dis.}^{\text{ce}} AB = 32 \text{ Ft}$$

$$\text{Centre of Grav.}^{\text{ty}} 16:32::10$$

$$BC = \frac{3 \times 10}{16} = 20 \text{ line 4} = 12 \text{ Ft}$$

$$BD = x$$

$$AD = 32 + x$$

$$\frac{S}{V} = \frac{32 + x}{4}$$

$$\frac{S}{V} = \frac{x}{2} = B$$

$$\frac{32 + x}{4} = \frac{x}{2} \text{ hence } 64 + 2x = 4x \cdot x = 32 = BD$$

$$\text{Then } DE = DB + BC = 32 + 20 = 52 \text{ Ft}$$

That is after the meeting the bodies
will move 52 Feet as much as each
of them employed going to D = 16 mts
To find the Ft divide $\frac{52}{16} = 3\frac{1}{4}$ Per Min

QED

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The annexed is a Machine to
illustrate the theory of percussive
bodies. - see fig 1st Page 50.

It consists of 2 upright Posts
or bae connecting them above
c is the centre from which
depends two elastic bodies moving
so as to describe the graduated
Arch AB which measures the
recoil of these bodies &c.

If for instance the body B be
raised to number 6. & A to 6.

If non elastic they will upon
meeting remain motionless.

If Elastic they will make
equal recoils (that is if the bodies
be equal) if ^{and one} non elastic, be
double the size of the other the

The greater body will upon 53
 being raised to an equal height
 impart to the smaller
 the half of its velocity $\frac{1}{2}v$ so on

Prop fig 1st Page 32

$$Aa + Bb = (A+B)x$$

$$x = \frac{Aa + Bb}{A+B} \text{ H. Vel After Collision}$$

$$\left. \begin{array}{l} 5 = A, B = 7 \\ 10 = a, b = 5 \\ \frac{a-b}{2} \end{array} \right\} \begin{array}{l} x = \frac{Aa - Bb}{2AB} = \frac{a+b}{2} \\ a-x = a \frac{Ba + Bb}{A+B} \end{array}$$

$$Aa + Ba - Aa \text{ -----}$$

Of Elastic Bodies

Although we are sufficiently
 acquainted with elastic bodies
 to make them subservient to
 our purposes, yet their pro-
 perty is not perfectly understood

Giving it in the Buffers own ³⁵⁷
words -

Let A & B = 2 Elastic bodies impelled
by equal & contrary forces, strike
each other at c, it is evident, the
elasticity of A will repel the body
from c to B & vice versa -

Therefore the two bodies will act
with equal elasticity & recede
with equal distances whereas
if non elastic they would they
would have remained stationary

Prop ~~the 5th~~ Page 54

When a body has struck another
it recedes with as much velocity as
it proceeded ~~~~~

$$x = \frac{Aa - Bc + 2Bb}{A+B}$$

$$y = \frac{Bb - AB - 2Aa}{A+B}$$

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Proposition

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If equal elastic bodies strike each other. They receive equal motion.

$$x = \frac{2a - a + 2b}{3} = \frac{a + 2b}{3}$$

$$\text{from } \frac{Aa - Ba + 2Bb}{A+B}$$

$$\frac{Aa + Ba - Aa + Ba - 2Bb}{A+B}$$

$$\frac{2Ba - 2Bb}{A+B} = 2B \left(\frac{a-b}{A+B} \right) = a - b - y - x$$

Proof

A & B two bodies

A = 2 pounds + velocity of 8 ft per second

B = 1 pound + velocity of 5 ft per second

Dist AB = 12 ft

find the dist BD

$$BD = x$$

$$\frac{x}{5} = \frac{x+12}{8}$$

$$\text{hence } 8x = 5x + 60$$

$$3x = 60. \text{ or } x = 20 = BD$$

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Dist $\overline{BD} = 20$ div. by the Velocity

$B = 5 - 4 =$ number/seconds in the Time the
bodies move from A & B to D

$$4 \overline{EC} = \overline{CD} = \overline{CB} + \overline{BD} = 8 + 20 = 28 \text{ - } 4$$

$$\overline{EA} = \overline{EC} - \overline{AC} = 28 - 4 = 24 \text{ div. by } 4$$

6 velocity A after the stroke from E to A

$$\text{Also } \overline{EB} = \overline{EC} + \overline{CB} = 28 + 8 = 36 \text{ div. by } 4$$

$9 = S - v. B.$ so that after the stroke the
bodies will move from A to B the same

way that $A = 6E \text{ \& } B 9 S$ —

If an elastic body ^(at rest) be interposed between
two bodies, & if one side one of the bo-
dies be made to strike the body in-
terposed, the striking body will
communicate its impulse to the
body on the other side of it —

see pag 58 — If the body B strike the
body A at rest, it will commu-
cate its motion to C —

Gravity

is that property of bodies tending to move towards the Earth.

Def. All bodies attract each other - again the attraction is proportionate to the quantity of matter -

When we speak of the weight of a body, it is when a body prevents another from falling towards the centre of the Earth. & the pressure is as the quantity of matter -

Let A weigh 3 pounds & B weigh 1 pound. the attraction to the Earth in B is as 3 to 1

It has been said that bodies gravitate towards the Earth - Example

Prop see fig 1 Page 60 62
Let DC be a straight line, upon a triangle
 DBC be described. I say the line AB bisects
it because CAB & DAB are right angles DBA
& CBA are equiangular. suppose the body
 B gravitates towards D equally, then
for the tendency of B to gravitate
to A . & in no other straight line

The action of Gravity upon a body
at rest, or one in motion on
the same —

Since the attraction is propor-
tioned to the quantity of matter
all sorts of bodies whatever be
their weights if they gravitate
towards the Earth from the same
height at the same time; they
are equally accelerated; for though
a body A be twice as heavy as a body

B if we conceive A to be divided into 64
two equal parts each of those parts must
be equal to B & must move through an
equal space. in an equal time. It is
evident that if ^{the} 2 parts be joined toge-
ther the effect must be the same. Hence
we may take it for granted that
all sorts of bodies would fall from the
same height in the same time if the
resistance of the air was not in propor-
tion to the Quantity of Matter.

To prove this take a tall Receiver
having at the top a piece of Mechan-
ism so constructed so as to contain
a Guinea and a Feather & place
it over a air Pump, Exhaust the
air, & it will be found on disengag-
ing ~~that~~ at the same instans) ^{that} they

will have descended ~~at~~ the same 66
time. This experiment at once proves
that all bodies gravitate equally in
vacuo. The attraction of the Earth has
been found to increase, this however
is undetermined —

Bodies that are left to fall from
any height, will move faster
& faster, the nearer they approach
to the Earth. according to the
laws of Motion. bodies continue to
describe equal Spaces in equal
portions of Time but the more
moment the force of gravity acts
on the body, so that the velocity is
doubled since the second impulse
is equal to the first & the first remains
unaltered, & again the 3rd moment

The Velocity is ~~double~~ ^{increased} ~~to~~ 68
as the Time increases, so will the
velocity, for the velocity is continually
increasing the Space must be
as the Time multiplied by the velocity
— Examp. see fig 1st Page 67

Complete the triangle ABC &
the Parallelogram DB —

Let AB be equal to the Time

B to the Velocity —

Draw the diagonal AC —

Let the line AB be divided into the parts

ef. ik. mn &c. or = vel^{ty} at the end of T

Ae. Ai. Am = T —

Time ef ÷ Velocity in the Time ie

ik ÷ Velocity in the Time im

Now the Space passed over in any
Time with any

velocity, is as the Velocity $\times$ by the Time

That is as the rectangle under that Time

and Velocity. Hence the Space passed

over in the Time im with the Velocity

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A1¹ 16.12

2" 64.48

3" 96.72 -

B

it will be as the rectangle m_k : the 7^{th}
space passed over in the time m_p with
the velocity m_n , as the rectangle p_n
&c but since the parts are infinitely
small, the sum of all the rectan-
gles are equal to the triangle
 ABC , now the space passed over in
the time AB with the velocity BC
is as the rectangle $ABCD = 2ABC$.

Therefore the space passed over
in a given time by a body is
equal to half the space passed
over in the same time with
an uniform velocity is equal
to that acquired by the body
at the end of its fall - Example

see fig 1st Page 69 - $16 \cdot 12$ is the
number of feet passed over in the
first second in the second second
 $64 \cdot 48$. The spaces passed over

are as the odd numbers. 1 3 5 7 & 9
it appears therefore that 96.72 is the
space fallen through in 3 seconds

A woods Machine—
see fig. opposite Page 73 AL

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Smeaton Machine similar ⁷⁴
in purpose to a woods —

We shall here terminate this
subject & proceed on to.

Projectiles —

Whatever body is impelled by
any power & is left to itself
is called a Projectile. A Ball
discharged from a Gun, a Shell
from a Mortar are called
projectile. It has been shown
that Projectiles unless they be thrown
perpendicular up or down, must
describe curved lines because
they are acted upon by two forces
viz the impelling force & the force
of gravity, the one tending to
produce an accelerating the

other a gravitating force. These 76
curves are Parabolas. But properly
speaking a perfect Parabola
can only be described in a Vacuum
for the resistance of the air &c
in a great measure, causes the Pro-
jectile to deviate considerably
from the Parabolic Curve
Exp - When a body is projected
obliquely from any kind of Engine
such as a Ball from a Cannon
see fig. Page 75. A in the direction
AC the force of gravity acting upon
it in the direction nearly per-
pendicular to the horizontal
plane a AB; ~~causes it to deviate~~
from the straight line AB & to de-
scribe the Parabola ADB falling
on the horizontal plane a FB

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so that it is evident that a Ball 72
projected from a Mortar cannot
for a moment move in a straight
line; except when the shot has ac-
quired a rotary motion owing
to the irregularity of its shape
or from some fault in the
barrel of the piece. it will be-
gunately deviate sideways
& even upward for a short
time. Hence the use of Bar
& Chain Shot - The distance
 AB is called the range of the Shot
 DE the height of the Parabola
 CAB the angle of elevation.

The time during which the shot
passes from A to B is called the
Time of Flight & B the point
where it strikes, the Momentum

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Prop see fig. 1st
Page 4x

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The spaces AF . AG . AH of passed over uniformly are as spaces AB . AC . AD &c
passed uniformly accelerated areas
the squares of the Time $AB:AC::$
 $AF^2:AG^2=BE^2:CM$ Therefore the proper
tile describes the $AEMN$ &c
NB. The greatest Horizontal range
is at 45°

The lower & upper elevation that strike
the same point are equally dis-
tant from 45° If the lower one is assumed
above as the other is below 90° ...

$$1: \cos B = a; CD = a \cos B$$

Mechanics

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is the science which treats of
quantity extension of Motion
The application of Motion
consists in the construction of
Machines for the purpose of
overcoming resistance or of moving
bodies -

2 bodies $A \& B$ are connected with
each other by means of a Rod
 AB resting on a point E , if the
Rod moves out of its horizontal dire-
ction in the position $C \& E$ the
body A will describe an arc AE
 B will describe another BE these
arcs will represent the velocities
of $A \& B$ therefore the motion is

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Continuation

*

$$2\pi \cdot CP :: \frac{BC \cdot B \cdot \sin D}{AB} :: 360^\circ : ECB$$

$$ECB = \frac{360^\circ \times BC \cdot \sin D}{2\pi \cdot CB \cdot AB} = \frac{188.0}{\pi \cdot AB}$$

$$\frac{180^\circ}{\pi} = 57.29577$$

$$ECB = 57.29 \times \frac{0}{AB}$$

of A is to that of B :: weight A + AE : If
 weigh B + BC. The velocities of A & B
 represented by their dist^o from E.
 for the arches are as the Radii.

The vel^o are represented by EG. CD
 for since the Triangles are similar
 that is EFG CDE. EF : EC :: GE : CD :: the
 mom^{ts} of A & B. may be represented
 by A + AE & B + BC or A + AE & B x BE or lastly
 A + EG & B + CD --- alg. brachy

Page 83 B : A :: AE : EB

$$x = v - A$$

$$AE : EB :: x \frac{EB \times x - v \times B}{AE}$$

$$\frac{B \times EB \times x}{AE} \text{ mom^{ts} of B} \quad \frac{v}{x}$$

$$\frac{B \times BE^2 \times x}{AE} = (Av - Ax) AE$$

$$\frac{v - x}{A} = \frac{v}{Av - Ax}$$

$$B \times BE^2 \times x = (Av + Ax) AE$$

$$B \times BE^2 \times x = B \times AE^2 + v - A \times AE^2 + x$$

$$B \times BE^2 \times x = B \times BE \times AE + BE - B \times BE + AE \times x$$

$$BE \times x = A + v - AE \times x$$

$$BE \times x + AE \times x = AE + v$$

$$BA \times x = AE + v$$

$$x = \frac{AE + v}{BA}$$

$$x = \frac{AE + v}{BA} \text{ the whole distance}$$

* opposite

Prop see fig 1st Page 80 86

$$A: BH$$

$$AB = a$$

$$AM = x$$

$$BM = a - x$$

$$HB: BE :: BM: MN$$

$$GA: AE :: AM: ML$$

$$GA \times ME = BE \times MN$$

$$GA: BE = MN: ML$$

$$Ax = B(a - x) = Ba - Bx$$

$$Ax + Bx = Ba$$

$$(A + B)x = \frac{Ba}{A + B}$$

Prop see fig 2nd Page 80

x =

$$\left. \begin{array}{l} (x-a)A \\ (x-b)B \\ (x+d)D \\ (x+e)E \end{array} \right\} \begin{array}{l} A(x-a) + B(x-b) = D(x+d) + E(x+e) \\ Ax - Aa + Bx - Bb = Dx - Dd + Ex + Ee \\ Ax + Bx + Dx + Ex = Aa + Bb + Dd + Ee \end{array}$$

$$x = \frac{Aa + Bb + Dd + Ee}{A + B + D + E}$$

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S is the centre of gravity —

see opposite figure Page 87

Of the simple method of finding
Mechanically, the centre of gravity
of irregular figures the opposite
will explain, it only by hanging
it ~~at~~ a point, from which a plummet
is also suspended. the centre
of gravity is easily found in the
plumb line — see fig 2nd Page 85

Prop

Given the number of sides
to find the centre of gravity

The number of sides 3. or Triangle
Let ABD be the given triangle bisect
BD & join AC bisect AB & from the angle
D draw the straight line DE & draw BE
parallel to AC, E is the centre of gravity

Because BE = AE

$$DC : DB :: CE : BE$$

[see fig 3rd Page 85]

Proposition

$$\text{but } AD = \frac{1}{2} DB \text{ \& } CE = BE \\ \text{\& } CE = \frac{1}{2} \text{ ~~AE~~ }$$

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$$\text{Therefore } CF = \frac{1}{3} AC -$$

To find the centre of Gravity of
a Pyramid. Let ADB be a Pyramid
bisect each of the angles $A \cdot D \cdot B$ & draw
the lines till they meet in a point
 C . bisect also the line CB in E join
 DE & AE take $FG = \frac{1}{3} AD$ join FG & EA .

we have $DE : EB :: AG : GE$

$$AD : DE :: FG : GE$$

$$FG \text{ was made } \frac{1}{3} AD$$

$$\text{therefore } GE = \frac{1}{3} DE$$

$$\therefore GE = \frac{1}{4} DE -$$

See fig 1st Page 89 -

The centre of gravity will always
be under the point of suspension

Let A be a circular piece of wood
in the circumference which is
inserted a piece of Lead, it is evident

91

That if the wood be placed in 92
the position D. the lead would
cause it to fall to the centre of
gravity C. again I represent
a cylinder of wood in the end
of which is inserted some lead &
C then is the centre of gravity of
the cylinder see fig 1st Page 91

If we place the cylinder with
the lead uppermost on an inclined
plane and allow the plummet
to suspend freely the cylinder in
the position in the position repre-
sented (fig 2 Page 91) will stand
because the centre of gravity is in the
line AB. But if we elevate the plane
as in fig 3rd pag 91) the cylinder will
fall because the line AB is beyond

93

the centre of gravity. The same is
in the case with an Octagon or
any other sided figure - See 1. Page 93
Base. In the same we find the lead
prevents the body from rolling
Down the Plane, two forces acting
equally the Gravitation and an
accelerating force. See fig 2nd Page 93
in the same manner the Experiment
of the cone is evident, which appears
to run upwards, but in reality
the force of Gravity in the prominent
part is making it run down, &
beyond a certain height it will
not run see fig 3rd Page 93rd

95

Aec to B

[Faint, illegible handwriting]

$$A \setminus AC - B \setminus BC$$

$$A \setminus AE - B \setminus BD$$

$$A \setminus EC - B \setminus CD$$

Prop.

If there be any system of bodies & if at any portion of Time we compute the motion of the one body with the different motions which the bodies would have acted on one another. & if also compute the motions which in consequence of the motion they really have in the instant the momentum which remains to be compounded with the other quantities to produce the second are such that if they only both acted on the system, they would produce no motion at all and preserve in Equilibrium

Propose figure 2nd Page 95

Dec 8th 1808

The number and variety of Machines are innumerable, but they all consist of certain parts of simple Machinery combined in various methods —

We may reckon the number of simple Machines to be six — Viz —

Lever	}	Inclined Plane —
Wheel		
Pulley		
Wedge		
Screw		
Funicular		

The action of all these powers depends upon the same principle

The Lever

is an inflexible Rod having an angular point, which is called

Fig

The fulcrum, it is used to overcome a given obstacle with a given power. Thus if a Man wanted to raise a certain weight, so as to pass a stone under it he would apply a Rod P , resting on the fulcrum F by exerting a force at P he would raise the weight W , in proportion as the Power used in the operation.

There are 3 different sorts of levers
1st when the fulcrum is placed between the weight & the power as above

2nd when the fulcrum is at one end of the weight between

3rd When the fulcrum is at one end the weight at the other and the power in the middle, fig 3rd & 4th

102

It must be observed in these 102
levers that the first is the most
powerful. 2nd the next & the 3rd
the least of all —

There is one however similar to
the first which has been called
by some a Mechanical power
of itself. but although different
in figure it is evidently a spe-
cimen of the first, see fig 5th Page 101

We shall here give a Propⁿ respecting
the last kind of Lever, but shall
suppose that instead of pressing
the Power is put ting downwards
see fig 2nd Page 100 —

$$AF \times AC = W \times BC$$

$$1: \sin i :: AD: AF$$

$$AF = AD \times \sin i = P \times \sin i$$

$$P \times AC \times \sin i = W \times B$$

AB is a lever of a kind where. 104
 the fulcrum is at c & D is the centre
 of gravity. The weight of the
 Rod is here taken into considera-
 tion. We have

$$AC + P + DC \times L = BC \times W$$

$$W = \frac{AC + P + DC \times L}{BC}$$

Fig 1st Page 103

When a lever is supported at its
 two extremities & the weight is
 suspended at a point within it the
 points A & B may be alternately
 considered, one as the power the
 other as the fulcrum. From which
 it may be inferred that the proportions
 of weights supported by one of the points
 is inversely, in proportion as the dis-
 tances $P \times CB$
 tances are

$$P \times AB = W \times AC$$

$$P' \times AB = W \times BC$$

$$P : P' :: AC : BC$$

opposite fig 2nd Page 103

Compound Levers

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CD. DG. GE. 3 levers - figs. Page 105

Let CA. DE. GR be each equal to one foot

AD. EG. KH = 3 Feet.

Then the weight of one pound will produce the effect of 3 pounds at G. & this will be equal to $3 \times 3 = 9$ at D. & at C = 27 Pounds which will be raised at H = 1 Pound.

The effect of this Machine may be calculated by setting down the proportion between the power & effect in each of the 3 levers the antecedents with the consequents together. The product will give the answer.

$$\begin{array}{l} \text{Virtual Velocity} \\ Aa \times AC = B \times BC \\ A \times Aa = B \times Bb \end{array} \left\{ \begin{array}{l} 1:3 \\ 1:3 \\ 1:3 \\ 1:27 \end{array} \right.$$

Fig 2. Page 105

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1899

The balance is a lever whose fulcrum is in the middle, & the weights are suspended at the two extremities, if the weights be equal the beam remains parallel to the horizon, but when one of the weights exceeds the other the arm in which the weight is suspended will descend. The Balance requires Justness, Sensibility & Stability. The friction should be as small as possible, if not the Sensibility will be much affected. The Beams axle must be exactly at right angles, it is necessary, that the axis should be truly level & the extremities in the same plane. The Beam as light & strong as possible to diminish the friction. on this account hollow cones of Brass are most suitable. Prop. fig. opposite. Page 107

$$AE = EB = a$$

$$CE = b$$

$$AKG = EKB = i$$

$$1: \cos i = AE: GE$$

$$1: \cos i = d: GE = a \cos i$$

$$1: \sin i = EC: CF$$

$$1: \sin i = b: CF = b \sin i$$

$$W \times GE = W \times b \sin i$$

$$GC = GE - CF = a \cos i - b \sin i$$

$$W b \sin i = q (a \cos i - b \sin i)$$

$$W b \sin i = q a \cos i - q b \sin i$$

$$W b \sin i + q b \sin i = q a \cos i$$

$$(W + q) b \sin i = q a \cos i$$

$$(W + q) b \tan i = q a \quad \frac{\sin}{\cos} = \tan i$$

$$\tan i = \frac{q a}{(W + q) b} = i$$

Steel Yard

is a lever of the first kind whose fulcrum is at A. The weight B is suspended always at the same distance from the centre of motion but the counterpoise E may be shifted any way along the arm AD so that a great many different weights may be ascertained by the same counterpoise E whose momentum increases in proportion as the distance from A. see figure 2nd Page 111

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Let the distances Ac & bc & the distance of the weights to be measured from the fulcrum be 2. the weights c & $B = 1$ Pound $\frac{5}{2}$ then the weight CB will be equal to 10 pounds. — fig 1st Page 111.

A Spring steel yard, or Dutch measure —

Wheel & Axle

consists of a cylinder AB & attached to which is a wheel, moving in the same centre. — see fig: 2nd Page 111.

$$AC : CE :: W : P$$

or in other words the arm at which the resistance acts is to the arm at which the Power acts as the Power to the resistance —

Pulley

consists of a wheel moveable round
an axis. immovably fixed Fig 1
N.B. no power is gained by this
The pulley BD is called a moveable
pulley. in this case, it is evident
power is gained, because the
hook E supports half the weight
W. see. Case 2nd Page 173—
3rd is much the same. excepting
that the direction of the power
is changed by the fixed Pulley
M. so that if W weighs 2 pounds P
must weigh 1 Pound to balance
it. If a little more Power be ad
^{to E} to the weight W it will be raised

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A Case is a frame containing
3 pulleys & having the weight
fastened to its hook. at the beam
is an immovable frame consisting
of 3 pulleys. here it is evident
that the rope must be shortened
in raising the weight 6 times
as much weight is raised &
therefore we infer that the

power ^P must move with 6
times as much velocity as the
weight W? see fig 1 Case 4th Page 115

It must here be remarked that
the principle defect of these Mechan-
ical powers. Labour is under is
Friction. Fig 2 Case 5 Page 115.
Consists of a fixed and moveable
pulley. but each of these performs

The office of 3 pulleys. & con ¹²⁰
sists of 3 grooves of unequal Dia
meters. the same Rope passes over
each of these and the power is
applied at P , —

It is evident in this construction
that in raising the weight 6
Powers must be shorted & there
fore the Power must move
through 6 times the space the
weight moves through, consequently
the equilibrium takes place
when the Power is equal to
6 times the weight W . —

Wedge —

is a species of Inclined Plane,
consisting of 2 inclined Planes joined
base to base. The use of this instru

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ment are various, viz to cleave ²⁰
Stone Wood Iron &c. & its application
is very extensive. for in Fact
knives - Saws & most other tools
are in reality Wedges under
different forms. A Wedge is
called an Isosceles or Scalene
wedge according as the faces
are either Isosceles or Scalene

The action of the wedge is par-
tly derived from the inclined
plane. see fig 1 oppos. ^{to} p. 119

Let AKD be the face of an Isosceles
Wedge $B \& E$. 2 forces pressing per-
pend. ^r to its sides, suppose the
Wedge driven down, as far as
 GLF , the forces $B \& E$ must be driven
to $O \& N$ with the lines $IA \& ON$
it is plain the lines being parallel ON
 $= IA$. hence IA will have gone as far as ON

L. Evans

$VN =$ to the power of the wedge. &
 $BO.FM =$ v. of the obstacle. P.P.D

Cor. the smaller the angle the
less will be the resistance —

Screws

may also be considered as a species
of the inclined plane, it being nothing
more than a coil about a cylinder
of the nut moves up and down the plane
in a circular direction. The screw
is distinguished in to 2, namely viz
Male & Female. The former is
the cylinder with threads. The
latter is the hollow screw fitting
it. The Power of this most
useful machine, is generally
a less fixed either to the screw
or Nut. In all cases the

Dec 20th 1808

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The equilibrium takes place
between the effect which is pro-
duced at the end of the Screw or
Nut of the power when the po-
wer is to the latter as the circum-
ference described by the power in
one revolution is to the distance
between two contiguous threads

Particulars-

Is merely an assemblage of Cordage
used to assist and track Jaws.

Proof

$$WE = AD + DB - AB -$$

$$Px = W(2\sqrt{a^2 - x^2} - 2a)$$

$$Px + 2Wx = 2W\sqrt{a^2 - x^2} + a^2$$

$$a(P + 2W) = 2W\sqrt{a^2 - x^2}$$

$$x^2(P + W)^2 = 4W^2(a^2 - x^2) = 4W^2a^2 + 4W^2x^2$$

$$x^2(P + 4PW + 4W^2)$$

$$x^2(P + 4PW) = 4W^2a^2$$

$$x = \frac{4W^2a^2}{P + 4PW}$$

$$x = \frac{2Wa}{\sqrt{P(P + 4W)}} \text{ value of } x$$

The power of this last Machine
is very great. the smallest power
exerted in the manner stated
is capable of raising any weight
in some degree. In practice is
much employed in ~~the~~ lifting
cordage, we know that when
a Rope extends from a ship
to any body on shore. for
instance a Horse or pulling
it, we perceive notwithstanding
that there is a considerable
bend in the Rope. & yet the ship
will move. It is evident some
force is applied somewhere occasion
the Rope to bend. & that force is
the weight of the Rope &c

powerful is that force. That the
rope will rather break than
stretch straight. and it must
be remarked that the longer
the rope the greater ^{is} the time

The frequently observe sailors
for instance when they wish
to tighten the sail. pull the
rope about the middle while
a man below winds up the
rope as it lengthens —

Having enumerated the
Mechanical powers we
shall make a short digression
upon the subject of Friction
before we proceed to Compound
Machines —

Friction

If a body be laid upon another and be moved along the surface of it, that body requires a certain force to move it along & that resistance is called Friction. That Friction is greater or less according to the irregularities or rather prominences of those bodies & various other causes as the change of figure by pressure &c. If a body be moved along a surface, a smaller surface will be found sufficient than if that body be shifted ~~to~~ ^{by} itself before moved. This is from an actual change of figure which is produced sooner

Structure

or later according to the nature of
the bodies. If 2 are two bodies. it
is evident the friction is occasioned
by pressure of the one upon another
& the inequalities of both
but if we endeavour to fill up
these cavities with some substance
as Black Lead. Tallow &c the
Friction is much diminished.

See the oppos^d Machine

The quantity of surface does not
materially affect the Friction
for in a small surface the par-
ticles of it sink deeper into those
of the other, whereas in the large
surface the particles although
more numerous do not sink so
deep.

Prop - fig 1 Page

$$AC: AB = R: \sin C$$

$$AC: AB = R: \sin i$$

$$W: AB = R: \sin i$$

$$AB = \text{fric} = W \sin i$$

FE therefore tends to make the body
descend

as are $DE: FE :: R: \tan i$

$$DE: FE :: P: \text{Friction}$$

$$P: f :: R: 24$$

$$0087: 24$$

$$009: 24$$

$$9: 240: 1: 30$$

If the surfaces of bodies could
be rendered perfectly smooth
and destitute of Friction, it would
be as easy to move a body along
a plane as upon wheels
but now wheels are used to overcome
the friction. The utility is very

great, it is from the friction
 of the mass having that which
 must resist that causes them
 to revolve. A Horse in a wheel
 connected as that carriage
 will draw ten times as much
 as he will on the bare ground
 But we shall have to treat
 more fully on this subject
 hereafter. Fig. 1 shows showing
 the resistance. P is the weight
 force is applied

Prop. - see fig. 2 Page 1.

$$P \cdot AC = W \times CB + W + W \cdot r$$

$$P \cdot AC = W \times CB + \frac{1}{3} r \cdot W + \frac{1}{3} r \cdot W$$

$$P \cdot AC = \frac{1}{3} b \cdot r - W \times CB + \frac{1}{3} r$$

$$P \cdot AC \cdot \frac{1}{3} r = W \times CB + \frac{1}{3} r$$

$$P = W \left(\frac{CB + \frac{1}{3} r}{AC \cdot \frac{1}{3} r} \right)$$

The friction of a rope round a cylinder
 is very great suppose the friction that

aries from one Arrow to

F. 4 F. 8 F. 16 F. 32 F.

1 2 3 4 5

gear

Dec 22nd
1808

Compound Machines

All Machines that connect an active force with a certain effect. however complicated they may be; will be found to consist of the mechanical powers variously combined. Many are the powers used to act these Machines in motion. we shall first begin with weights and commence with a very simple but powerful machine used for raising weights or overcoming resistances by means of a lever applied to the Machine

If great power may be obtained
by the following calculation
see fig opposite.

CB = Radius of large Circle

AC = Radius of small Circle

DC = Lever see section

$1: \pi - 2R : 2\pi R = \text{cir.}^{\text{e}} \text{ of large Barrel}$

..... $2\pi R = \text{cir.}^{\text{e}} \text{ of small Barrel}$

$2\pi r \text{ or } 2\pi R - 2\pi(R-r) = \text{Diff. between the two Barrels}$

$\frac{2\pi(R-r)}{2} = \pi(R-r) = \text{arc of length for}$

one revolution Power

$P \times 2\pi L = W \times \pi(R-r)$

$P \times 2L = W(R-r)$

$P: W :: R-r: 2L$

Several Compounds are here
represented in Models
Pumping Machines
Parallel Motion
& All Engines

Animal Force

comes first to hand relating
chiefly to the power & subject
Others powers. as. The power
of running Water. of Wind
& I am I will be treated of here
after under the heads of Hydraul-
ics & Hydrostatics. Animal
Force is so much employed every
day that is instinctive we may
say. a horse teaches us to put
it in practice with regard to ad-
vantages. relative to different
works. when a horse walks
or runs. In the former case
raises one of his feet the other resting
on the ground. in the latter, both
feet are raised, in either way

It forms a succession of curved
lines. The centre of gravity being
always raised from the ground

The higher that centre of gravity
is raised the greater is the exertion.
Pedestrians are well aware of
this. as in performing a feat
they endeavour to avoid ~~as much~~
~~as possible~~ raising the centre
of gravity & always keeping
their feet as near to the ground
as they can. so that they may
be said rather to shuffle than
run. supposing a man moving
up a hill the centre of gravity
is always in a line perpen-
dicular to AB. Fig. 1.

The opposite is a Proposition to
the preceding
algebraically

Call $AB = v$ when the animal
 carries no weight

$$AB = c$$

$AE = W$ when the animal is able to carry
 P the power of the animal

$$C : C \cdot v :: P : W$$

$$W = \frac{P \cdot C \cdot v}{C}$$

$$W \cdot v = \frac{P \cdot C \cdot v^2}{C}$$

The effect of the animals force is as
 the rectangle under $AC \cdot CB$

Inclined Plane

To find in what time the body
 is accelerated — see Prop of fig 2^d

The time of a bodys descending the
 whole length of the inclined plane
 is to the time of its descending per-
 pendicularly as the length
 of the Plane to its height

Prop see fig 1. ^{Si} opposite

Of the general properties of
bodies uniformly accelerated
down the incline Plane.

Abstractly

$$v = \sqrt{2gS} = \sqrt{2gS \sin i}$$

$$v = \sqrt{2fS}$$

$$v = \sqrt{2gS \times \sin i}$$

$$S : S' :: \sin i : 1$$

$$DC : CE :: R \sin i$$

$$AC : CD :: R \sin i$$

$$BE : CE :: R \sin i$$

$$t = \sqrt{2S}$$

$$t = \frac{\sqrt{2S'}}{g \sin i}$$

$$\frac{2S}{g} = \frac{2S'}{g \sin i}$$

$$S = \frac{S'}{\sin i}$$

$$S : \sin i = S'$$

$$S : S' :: R : \sin i$$

c

Pendulums

consists of a body hanging at the end of a string & moveable about a point of suspension

It may consist of a body suspended without any string, as a Rod of wood or Iron. If a Pendulum be moved at any distance from its natural line of suspension & be there let go... It will descend towards the perpendicular, & having acquired a velocity, it will continue to move backwards & forwards. till at length it is overcome by the resistance of the Air, & the friction against the point of suspension, it

will gradually lose its velocity & at last return to its natural state. If these two obstacles could be overcome it would move forever.

Experiments have been tried where the Pendulum continued to move 32 hours.

Vibrations of all Pendulums of equal lengths are equal.

Of Pendulums there are 2 kinds viz. Simple & Compound Pendulum.

The simple Pendulum is when the weight is at the extremity. The Compound when there is a succession of weights, or when the

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Pendulum is of uniform
density the whole way up
as a steel Bar. or in the
figure represented. being
such that if the certain
point be struck the Pendu-
lum shall neither be accel-
erated nor retarded. To illus-
trate which the following
Prop. next to this will prove
Prop.

To prove that the time which
AD takes to make one vibration
is equal to the time of its
falling from A to B. which
is so evident that a complicated
Demonstration is unnecessary

$$T = \pi \sqrt{\frac{L}{g}}$$

$$T:T' = \sqrt{L}:\sqrt{L'}$$

$$T^2:T'^2 = L:L'$$

$$T:T' \sqrt{g}:\sqrt{g}$$

$$T^2:T'^2 :: g:g$$

$$T^2:T'^2 :: g:g$$

$$n:n'$$

number of vibrations

$$T^2:T'^2 :: n^2:n'^2$$

$$n^2:n'^2 :: g:g$$

The sq^s of the vibrations are as
the force of gravity

$$T = \pi \sqrt{\frac{L}{g}}$$

$$1:\pi :: \sqrt{\frac{L}{g}}:T \quad \pi \times 1 = \pi \sqrt{\frac{L}{g}}$$

$$2\sqrt{\frac{2L}{g}}:2' = \sqrt{\frac{4L}{g}}$$

$$T^2 = \pi^2 \frac{L}{g}$$

$$g = \frac{\pi^2 L}{T^2}$$

$$g = \frac{\pi^2 L}{T^2}$$

$$L \times \pi^2 = T^2 \cdot g$$

$$T = \frac{T^2 \cdot g}{\pi^2}$$

$$L \propto \frac{g}{\pi^2}$$

$$g = 32.174$$

To find the point between them
such that it shall neither be
accelerated nor retarded.

c = celerity

$c-v$ the velocity it loses

$AC = a$

$BC = b$

$CO = c$

$$a : b :: v : \frac{bv}{a} = \text{vel } B$$

$$\frac{bv}{a} - c - *$$

Proof.

That 2 pendulums ^{of equal length} vibrate
in equal times independent
of their weights —

$$\begin{array}{r} 9 \cdot 4 \\ 4 \cdot 4 \\ \hline 36 \quad 16 \\ 6 \sim 4 \\ 3 \sim 2 \end{array}$$

By lowering B it will be found that
at the end of 4 vibrations B will
coincide with A —

Centre of Oscillation

or at what point the 2 pendulums form one. —

$$AC = a$$

$$BC = b : CO = x$$

$$x : a :: c : \frac{ac}{x}$$

$$x : b :: c : \frac{bc}{x}$$

$$C\cancel{O} - \frac{AC}{x} = \frac{Cx - ac}{x} ; A \left(\frac{Cx - ac}{x} \right)$$

$$\frac{bc}{x} - c = \frac{bc - cx}{x} ; B \left(\frac{bc - cx}{x} \right)$$

$$\frac{A \cdot a (Cx - ac)}{x} = \frac{Bb (bc - cx)}{x}$$

$$A \cdot a (Cx - ac) = Bb (bc - cx)$$

$$A \cdot ax - Aa^2 Bb^2 = Bbx$$

$$Aax + Bbx = Aa^2 + Bb^2$$

$$x + (Aa + Bb) = Aa^2 + Bb^2$$

$$x = \frac{Aa^2 + Bb^2}{Aa + Bb}$$

$$x' = \frac{a^2 + b^2}{a + b}$$

Strength of Materials
 by absolute strength of Timber
 we mean the resistance of
 the fibres of Wood in be drawn
 asunder. By Relative strength
 we mean the resistance in
 crushing the wood—we shall
 here give a table of the quan-
 tity of power necessary in
 separating various materials
 by square Inches of each

Metals—

Gold — — — —	{ 20000
Silver — — — —	{ 24000
Swed. Copper — —	{ 42000
	{ 40000
Japan ⁿ Copper — —	{ 37000
	{ 19500
Cast Iron — — —	{ 42000
Brit. Do — — — —	{ 59000

Ordinary Bar Iron — — 68,000

Sweet & Rusty Do — — — 84,000

Soft Steel — — — 120,000

Hard Do — — — 150,000

Tin — — — 6,000

Lead — — — 850

5th of Gold to 1st of Copper. 50,000

6th of Copper to 1st of Tin — 60,000

Copper. 1 of Brass 51,000

Common Wood. — — —

Oak — — — 17,000

Beech — — — 17,000

Alder — — — 13,900

Elm — — — 12,200

Ash — — — 12,000

Fir ————— .8330

Cedar ————— .4880

All These were ascertained by
actual experiments —

Buffon however found, gum
wood had far the greatest
cohesion —————

Prop.

$$AB = d$$

$$AC = a$$

$$F \times AB = W \times BD$$

$$W = F \cdot \frac{AB}{BC}$$

$$W = F \cdot \frac{BE}{BD}$$

$$W = \frac{ABG}{BD} = \frac{\Delta GAB \times b \times AB}{BD} = \frac{F \times \frac{d}{2} \times d \times b}{a} =$$

$$\frac{F d^2 b}{2a} \therefore \text{Relative strength}$$

$F d b :: \frac{d}{2a} : 1 :: d : 2a$ Absolute strength
The absolute strength is the relative
strength as 2nd the length of the

beam to the difference

$$+B \cdot b d \cdot \frac{1}{2} b = W a$$

$$\frac{F d^2 b}{2} = W a$$

$$W = \frac{F d^2 b}{2 a}$$

$$\frac{F \pi r^2 \times 2}{a} \quad \frac{F \pi r^3}{a}$$

$$\frac{1}{2} F \cdot b d \times \frac{2}{3} d = \frac{F b d^2}{3 a}$$

Cylinder of Ring

$$\frac{F \pi r^3}{a} \therefore \text{inter Radius of Ring } m.$$

$$\frac{F \pi r^2 \times m}{a} \quad \text{External Radius } m'$$

The Machine above is used to
 try the strength of Timber by a sin-
 gle lever. The strength of the beam
 is inversely as the length

$$\begin{array}{r} 2 \\ 65 \\ \hline 72 \end{array}$$

Assuming the strength of the Rod
 100:72

24 June

Dear Sir

I have the honor to acknowledge the receipt of your letter of the 24th inst. in relation to the above named matter. I am sorry that I am unable to give you the information you desire at this time, but I will endeavor to do so as soon as possible.

Arches

The arch in its position
weight to bear may be considered
as the inversion of a chain sus-
pended at each end for the chain
hangs in such a form that the
weight of each link, is held in
equilibrium by the result of two
forces acting at its extremities -
suppose ~~that~~ this chain were in-
verted & to continue in the same
form, an arch. The relative posi-
tions of the line showing the
directions of the forces would be
the same, the forces acting only
in contrary directions. The only
difference of ~~either~~ would be
that the chain would be stable

This propos. is much on the same principle
of an Arch

The cords AB & AC may be converted into the Props
AK & AE it would support the load at D

but the arch tottering. This figure
is called the catenarian Arch

An Arch may be said to consist
of a combination of Wedges
each acting with a force upon the
other. Many instances are known
of Rubbish & stones frequently
falling and supporting itself in
equilibrium. The Egyptians do
~~not seem to have been~~ - we may
judge from the structure of their
Buildings) appear to have been
acquainted with arches, the
oldest Arch however is to be found
at Athens, and ^{we} have many
instances to this day of the dura-
bility of them. A Bridge should
be able to support itself without
being in danger of falling by
the lateral adhesion of its piers

$G:H::AD:DE$
 $AD:FG::Q:L$. *gec.* -

that it may be equal throughout
its depth at each point should be equal
to the parts beyond it. If the strength
depended only on the arch stones it would
be necessary to give them requisite

thickness independently of the
general form of the arch. The best
curve for resisting the pressure
of a fluid is the elliptic the loga-
rithmic & the Parabolic curve
for a road the elliptic is different
a little from the circle is best

The Equilibrium of a Bridge is
naturally tottering. If the smallest
force which is capable of de-
stroying it, may destroy the struc-
ture. The Abutments ought
to be sufficiently strong to support
the whole. If much damage will
ensue. It is necessary also that
the Piers of Bridges should be so
firm as to support not only the
weight of half of each adjoining
Arch, but also to sustain (in case

of one of them failing) the horizon
tal thrust of the other, must remain
to be said upon this subject, there is
however a most excellent treatise
by the Encyclopedia Britannica
where the subject given at large.
Figure opposite shows the gene
ral method of constructing the
electric curve. We will now
proceed to the subject of -

Hydrostatics

treats of the pressure & equilibrium
of non elastic fluids. Hydrodynamics
treats fluids in motion, & Hy
draulics of the construction of
Machines in which fluids
are concerned. A perfect fluid
is that whose parts may be
moved by the smallest force, but
there is no such thing existing

The surface of every fluid when
left to itself falls away in a
line perpendicular to the cen-
tre of gravity, or. horizontal
But when the water is curved
as in the fig 1 - oppos^t it is con-
stantly in motion. It may be resolved
into two forces the one the one
a tang^t to the curve AF the per-
pendicular the force of gravity, so
that while in this positⁿ it will be
in motion - Case 2nd the fluid is
at rest being horizontal. again
If we consider a circular globe sur-
rounded by the etha. the surface
of it must be every ^{where} at right an-
gles to the centre of gravity.

In the next experiment. that
if a fluid in a vessel acted upon
by gravity, the particles are equal

pressed. If we put a hole in a
 vessel the water will issue
 with equal velocity in any
 direction whatever. see fig-104
 Next Prop. supposing a fluid ^{tends}
~~move~~ ~~round~~ two points see fig 2

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The pressure of a fluid is
 in proportion to its perpendi-
 cular height. It is exerted in ev-
 ery direction, so that all parts
 of the same fluid at the same
 depth, press each other with
 equal force in every direction
 see fig 3rd the force FE is the
 weight of D . the $\angle GFE = DEF$

$$GF : FE :: AE : AD$$

GF = weight of water in the vessel

$$AE : FE :: AB : AD$$

and $AD = FE$

figures opposite represent the
pressure of fluid in various
ways. ~~Fig~~^{Fig} 2nd represents
the method on which banks
of Canals Water Pumps &c
ought to be constructed -

Fig 3th represents the pressure
of a column of Water on a
Vessel filled full, having
an aperture at the bottom con-
taining the column. The power
of this column may be increased
prodigiously, for in Fig 4th opp^{to}
the pressure of the column of wa-
ter in the Tube is equal to the
whole body of water as represented
by the dotted lines on a level with
the surface of water contained in

A	E	N	M	B
	G	F	O	
D	H	K	E	C

the text - hence we have added
a seventh. Mechanical power,
if it must be observed that
after this theory is constructed
Bernoulli's Press — — —

We must here observe that as
fluids press in every direction
at the same depth the particles
of it press in equally in ~~every~~ ^{all} directions
thus —

Prop.

a body floating in a fluid
displaces a quantity of it equal
to its own bulk, thus let ENGF be
a body floating in a fluid, weighs
as much as it displaces. for the
body is kept in that place by the
pressure of the surrounding
water — — —

which pressure is equivalent
to the space displaced by the
body. ~~ENCE~~, therefore the weight
of that fluid is to the weight
of the body - From this is de-
duced several corollaries -

1st If the same body be put in
fluids of different specific gravities
it will sink in light than
heavy fluids -

2 If the weight of that body be
equal to its weight of water
it will remain at rest in
any part of the fluid below the
surface -

3 If a body heavier than an equal
bulk of a fluid is placed on the
surface it will sink with the
excess of weight ^{which the body is} heavier than

than its equal bulk of fluid
hence a body weighing 3 pounds
in air, will weigh but 1 in water
where to ascertain the specific
gravity of a body, divide by the
weight it loses in water, & it gives
the answer —

4 If a body lighter than its bulk
of fluid be placed at the bottom
of a vessel containing that fluid
that body will ascend with
more or less force, according as the
difference between the weight
of the body & its equal bulk of
fluid is greater or less —

5 If a body be placed successively
in 2 different kinds of fluids
the parts of that body which
are immersed in them, are in

versely as the specific grav^s of
the fluids —

6 When a solid is floating upon
a fluid the part immersed is to
the whole solid as the specific
grav^s of the solid to that of the fluid
for when the spec^s grav^s is to
that of the fluid. the solid dis-
places a quantity of fluid equal
to its own bulk —

7 All bodies retain their ~~weight~~
when immersed in a fluid
& when we speak of weight lost
by the body we mean the bouy-
ancy of the water. according as
the gravity of the immersed bo-
dy is equal or different from

that of an equal bulk of fluid

Prop is when the immersed body is supposed to sink -

The body E is acted upon by two forces the weight E & the buoyancy of the water

$$E - E = ON = W$$

$$E - W = E$$

now

We shall illustrate the specific gravities of bodies by experiment with the instrument called the Hydrostatic Balance as represented in the next Page when the body to be ascertained, is first weighed in

air it is again attached to
the Balance and weighed in
Rain or distilled Water ^{at Tempⁿ 62°} its weight
in the last case be found to
have lost a considerable por-
tion of its weight, which in
reality is nothing more than
the buoyancy of the fluid

Fig. 1. opp. to repres.^{ts} a method of as-
certaining the specific gravity
of a body - suppose a body (fitting a
brass bucket exactly) be weighed
first in Air, afterwards in
water: in the latter case the weight
of the body is insufficient to keep
the Balance in equilibrium, now

Table of Specific Gravities -

Metals		Wood	
Platina -	19.5		
Gold -	19.2	Heart Oak ^{sp.} 60	1.17
Silver -	10.474	Elm	.67
Best Copper -	7.7788	Fir	.55
Iron -	7.7880	Swed. Fir	.44
Steel -	7.8331	Fluids	
Lead -	11.3528	Pt Wine	.798
Corn. l. Steel -	7.2914	Sea Water	1.026
Zinc	7.1904	Turpentine	.991
Fluid. Mercury	13.5681	Liv Oil	.940
Stones		Whale Oil	.923
Orien. Ruby	4.2833	Cows. Milk	1.033
Topaz	4.0606	Ice	
Diamond	3.5212		
Rock Crystal	2.653		
Fire Stone	2.415		
Red Egyptian Granite	2.6541		
Ponderous Spar	4.4409		

it is evident the body displaces water
 equal to its weight therefore it
 is necessary the Bucket should
 be filled with the fluid to keep
 the opposite Scale in equilibrium
 consequently the body has lost
 the weight of the water con-
 tained in the bucket. This however
 is subject to many inconveniences
 as the difficulty of having the
 bucket to fit the body &c.

We shall therefore substitute
 a different Balance in possession
 of Mr. Gardiner^{of} Prof.

to find the specific gravity
 of a body -

$$W:W':W:S:S.$$

$$(W-W')S = W'$$

$$S = \frac{W'}{W-W'}$$

Prop -

Having a piece of Elm weighing
 in air 920 connected with a
 piece of lead weighing 1000 Gr^s
 & suppose the compound weighing
 in air 1920 which in Water
 would weigh 332 Grains -

	1920	
	332	
1499	<u>1588</u>	Bouy ^t of Water
	89	weight lost by lead in
	1499	w ^t of water = ^{lost water} to the
		bulk of Elm

~~1499~~ 1499 : 920 :: 1 : 613

1499	) 920	(.613
	8994	
	<u>2060</u>	
	1499	
	<u>5610</u>	
	4497	
	<u>3</u>	

An Instrument called the
drometer, as used by the
diales is here represented, which
consists of a brass or glass ball
kept in an upright position
by means of the weight below
to which is attached a stem
graduated. The specific gravity
is ascertained by the depth to
which the instrument sinks
in the fluid, which is marked
by the degrees on the stem
either sinks or rises accor-
ding as the fluid is lighter
or heavier. Several
Instruments of this sort
have been invented, among
which is the Gravimeter

much in use among Mineralogists
 for ascertaining the Specific Gravities
 of Minerals &c. on the stem
 is a red mark (at which) when the
 the instrument sinks the exper-
 iment is ascertained upon
 the. Call is marked 1200 Grains.
 The body to be ascertained is either
 placed at the top or bottom as is
 necessary either to weigh in
 in Air or Water

A Cubic Inch of Water
 weighs at 60° (252.47 Grains)
 Barometer 29.74

From all the preceding ex-
 periments it must appear evident
 that a body in Vacuum is heavier

that in air. because the buoyancy of the ~~dis~~tracts upon the same principle as that of water

$$W + \frac{W'}{820} + S \text{ in vacuo.}$$

$$W + \frac{W'}{820S} - W'$$

having a bent Tube
fill one part with Oil
the other with water
the column of Water
will support 2nd its height
of oil

because Oil is lighter than Water

$$\text{Then } AB \times S = CD \times S'$$

$$AB : CD :: S' : S$$

The next subject we shall treat
of is that of Bodies Floating in
Water

When a body floats upon a fluid it will remain at rest with that part of the surface that lies nearest to the centre of gravity hence a sphere will remain with that part of its surface, with which it is first situated for the centre

of gravity is equally distant from all points of it, a cylinder will rest with its axis parallel to the surface, as a Cask—

2^d When a body floats upon a fluid, the centre of gravity of the part immersed will be in a line perpendicular to the centre of gravity with the

The fluid -
Prop.

Fig below represents a triangle
floating upon a fluid which
shows the different forces ac-
ting upon it.

Capillary Attraction

These experiments must be tried
with tubes of a very small bore.
Cap. If you immerse one end of
a tube in a vessel of water the
water will be found to have risen
up part of the tube, now the question
is, by what means, and in what

manner is this Phenomena to
be explained? the anacrisis
large attractor, to prove this
Let AB be the section of a piece of
glass immersed in the fluid BC . conceive this
surface div. into the parts
 a, b, c, d &c. the part a next
to the surface will raise
a small portion of fluid by its attrac-
tive force, but this quantity is brought
near to b the glass & is attracted by
it, again the first quantity being
raised to b is nearer to c hence it is at-
tracted by it and raised to c whilst the
quantity of water at a takes its place
and another quantity takes its

place and so on —

in plates of glass the Phenomena is similar as in this case we may consider the surface as a succession of Tubes

$$AB : d :: x : y = \frac{dx}{AB}$$

$$d : \frac{dx}{AB} :: Z : h$$

$$1 : \frac{x}{AB} :: Z : h$$

$$\frac{xZ}{AB} = h$$

$$xZ = AB \cdot h$$

In this last case the water will be found to have described an Hyperbola - the Altitudes are inversely as the distances of the plates of glass

Much could be said upon this subject but the limits of elementary Philosophy will not allow us to discuss the subject more widely

Prop

$$r \cdot a$$

$$ar = c$$

$$E - Br$$

$$\pi ar^2 = Br$$

$$\pi ar = Br$$

$$ar = \frac{B}{\pi}$$

Phenomena of Compound
Capillary Tubes

Prop -

supposes bodies to move through
unequal spaces with equal
velocities

$$\text{the force at } A = \frac{1}{2} B$$

$$\text{rec. und } AB \cdot AE = v^2$$

$$\text{und } AB \cdot BG$$

B

F
T
E

Supposing a Pipe 44 Inches long
 & 2 in diamⁿ. how much does it
 deliver in a certain time -
 make $Q = \pi \cdot \text{area of circle}$

$$Q = \pi \cdot \sqrt{2 \times 386 \times 5.28}$$

32	44
12	12
384	528
12	
12608	

The subject that comes next
 to hand is that which treats
 of the suspension of fluids

As this is a subject that
 requires to be entered largely
 upon it would take too much
 time to explain in an elementary
 course. The various phenomena
 illustrative of it, we shall

for the present confine ourselves
to a few observations upon
the subject of water wheels
a stream of water that issues
from an aperture in a vessel
has a tendency to carry away
in its direction other fluids &
light substance opposed to its
progress, that the water ^{acts} not
only with the pressure of
that contained in the reservoir
but with a certain velocity
communicated to it, both
by the force of gravity and that
of pressure is evident. Now
the ingenuity of man has

endeavouring to profit by this
in the construction of the way
which the invention of which
has proved of the highest im-
portance to the interests &
uses of Mankind. Of Water
Wheels there are several
kinds the most universal
however is the common
undershot wheel it is set in
motion by the velocity of Water
running under it from a
= clevity & striking the float
boards opposed to its progress
The drawing however will
more clearly illustrate the

Undershot Wheel

Overshot Wheel

To calculate its power
suppose -

$$\sqrt{16} : \sqrt{4} :: 32 \text{ w } 1^{\frac{1}{4}} : 16$$

$$\frac{16}{3} = 5\frac{1}{3} \text{ w } 1^{\frac{1}{4}} \text{ of w } \text{but.}$$

$$\begin{array}{r} 53 \overline{) 364} \quad (7 \\ \underline{371} \end{array}$$

$$\begin{array}{r} 7 \overline{) 60''} \\ \underline{56} \end{array} \text{ w } 1^{\frac{1}{4}} \text{ in 1 minute}$$

Another kind is called the
breast Mill -

In breast mills the water falls
perpendicular to the float board
in overshot Mills the motion is
communicated by the weight of the
water poured in buckets round its
circumference from above, An un-
dershot Mill requires the

most water to supply it. An ^{over}shot
shot. will the least.

The Water Wheel must not be
too large or its motion
will be too slow. nor too
small or its motion will be
too fast. It will want power.
The wheel should revolve with
one third of the velocity of
the water. In an overshot
wheel the same attention is to be
paid. The wheel should not
revolve too fast as by that
means the water requires a cen-
rifugal force & much of the
water is thrown from the buckets
consequently much power will
be lost. & the filling of the bucket

kets will be incomplete.

The greatest power in an arm
is at A. When C is obtained with
half the circumference or man-
ly so is filled with water, which
may be said to press upon the
lever, or arm AC with the col-
or of water meeting a tangent
from the point E at right
angles to it. Much remains
to be said on this subject. a most
excellent ^{treatise} is to be found on this
subject by the late Wth Smes-
ton, who with that ingenuity
peculiar to him was probably
the most fit person to examine

There remains a prop.ⁿ or two to
illustrate the theory of Orvesh
Whirls—

$$S = \frac{W}{W-W} \text{ value of } S$$

$$\frac{W}{820 S \cdot g} = \frac{W \cdot 00122}{S}$$

$$S + S = \frac{W}{W-W} + \frac{W \cdot 00122}{S}$$

Prop.

$$\frac{A (c-v)^2}{2-g} v \quad v = \frac{c}{3}$$

$$y^2 = 2gS$$

$$S = \frac{y^2}{2g}$$

$$\frac{A}{2g} (c-v)^2 v$$

$$\left(\frac{2}{3}c\right)^2 \cdot \frac{1}{3}c = \frac{4}{27}c^3$$

$$v = \frac{c}{3} + y$$

$$\left(c - \frac{c}{3} - y\right)^2 \left(\frac{c}{3} + y\right)$$

$$\left(\frac{2}{3}c - y\right)^2 \left(\frac{c}{3} + y\right)$$

$$\frac{4c^2}{9} - \frac{4cy}{3} + y^2$$

*

$$\left\{ \begin{array}{l} \frac{c}{3} + y \\ \frac{4c^3}{27} - \frac{4c^2y}{9} + \frac{cy^2}{3} \\ + \frac{4cy^2}{9} - \frac{4cy^2}{3} + y^3 \\ \frac{4c^3}{27} - \frac{4cy^2}{3} + y^3 \end{array} \right.$$

Off. of the 1/3 of v. of W

The Earth is surrounded by
a fluid called air which though
not apparent, is manifest in
several ways. It is that invisible
substance with which all ani-
mals are surrounded. It gravi-
tates, and its pressure is very
considerable. Air is absolutely
necessary to the support of
animal life. to combustion
&c. These however are parts of
its Chemical properties, where
its Gravity, Compressibility
&c are its Mechanical properties

thus. That the air has gravity is
evident. Ex. If we take a tube
having a piston within it, &
suppose the piston to be at
the bottom of the tube. If
in this condition the lower
of the tube be immersed in a
fluid, it will be found that
upon raising the piston
the water will follow it
up the tube. but let the tube
be ever so long the water will
not rise higher than 33 ft.
consequently the pressure of
the air is equal ^{that of} to a column

of water of 33 ft in height. the
same Experiment will answer
with a column of Mercury
but which ^{will} not be found to
rise higher than $29\frac{1}{2}$ Inches
remembering that the specific
gravity of Mercury 13.6 times
than its equal bulk of Water
therefore $29\frac{1}{2} = \text{Pres.}^{\circ}$ of Air -

If the tube be 31 Inches long &
filled with Mercury. & if filled
(the tube must be hermetically
sealed at one end) and one end in-
verted (with the open end down-
wards) in a basin of Mercury
then Mercury in the tube will

fall to $29\frac{1}{2}$ of the remaining
will be a vacuum, this is the
most perfect of all Vacuums.

The Instrument described is
called a Barometer, or measur-
er of the weight of the Air.

There are various methods of
constructing them & may be
easily obtained according to
the persons taste, the Barometer
has now become a considerable
appendage to a house not only
in possession of scientific people
but of considerable utility to
Gentlemen Farmers &c.

by which it is used to indicate
the state of the Weather -

1. In calm weather, inclined to
Rain the ^{Mercury in the} Barometer is low
- 2 In good weather the Mercury is
high —
- 3 In windy weather the Mer-
cury falls very low, with rela-
tion to the point it stands low
- 4 In calm frosty weather the
Mercury stands high
- 5 After stormy weather the Mer-
cury generally rises fast -

There are many other observa-
tions necessary, but the rise & fall

A geometric diagram featuring a vertical line with points labeled A, B, C, D, N, and P from bottom to top. Horizontal segments are drawn from these points: BE from B, CG from C, and EI from E. A rectangle DGI is shaded with diagonal lines, where D is on the vertical line, G is on the segment CG, and I is on the segment EI. A horizontal segment PN is also shown at the top.

as the density at B:
Density of air at C :: BE:CF

$$\begin{aligned} DB &= \log BE - \log DG \\ DB &= m \log b - \log m / \beta \\ H &= m \log 30 - \log 29 \end{aligned} \quad m = \frac{H}{D}$$

The pressure of the atmosphere
may be said to be all round
to the eq^d. but as it pre-
sses equally in all directions
no inconvenience upon the
human body is felt. If we
take away part of the pressure
by some means or other, as
for instance to place his hand
over an open receiver of an air
pump. as the air contained
within being withdrawn
the hand will be pressed
the Receiver so tight as to be al-
most impossible to withdraw

having proved its pressure
 it remains to prove its compress-
 ibility - & this experiment will
 show its compressibility, for if
 we take a bent Tube hermetical-
 ly sealed at the shorter end
 in which Mercury is already
 at the level GE . If more Mer-
 cury be poured in the tube it
 will condense the Air contained
 in the space GE - & the density
 of the given quantity of Air is in-
 versely as the compressing force.

thus. If a certain weight
 so much Air. Since this
 compress it an quarter of it
 & so on
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compresses
 weight with
 bulk &c.

Experience has shown that the
atmosphere which surrounds
the Earth is of different densi-
ties. And various experiments have
authorised ^{us} to suppose that air
at all distances from the Earth
is more or less dense; accord-
ing as it is situated nearer to, or far-
ther from it, or in other words
as it is pressed by a greater or
lesser weight of superincumbent
air. This density however, from
the vast expansion of air leads
only in conjectures with respect
to its height. Suppose the air

at a certain altitude be half
as dense as at the surface of the
Earth. Then at twice that al-
titude the air will be four
times as dense as on the surface
of sea. Having a knowledge of
this last formula, it leads to me
more certain & more expeditious
than the long laborious calcu-
lation, of the above, than is the
measurement of heights by the
Barometer. From the foregoing
description of this instrument
we may infer that the altitude
the ^{Barometer} ~~Barometer~~ will not be so great
as that in a Barometer placed on

the Sea Shore. Now those altitudes being as the densities, & the density on the Sea Shore being called one; we say as the height of the Barometer at the surface is to the height of the Barometer on the Mountain so is one to the density of the Air on the top of the Mountain. Finding the density thus obtained in the Table, we have the perpendicular distance between the situations of the Barometers. There is much more than this however to be done, in measuring heights, as the

general method is extremely tedious
 the following one by Professor
 Playfair may be more accep-
 table.

Barometer 29.555-

Thermometer 33

Barometer at Top of A. ^{rs} Lat 28.770

Thermometer $^{\circ}$ --- 31.3/4

Log 470.6310

458 9399

11 6 911

6
 701466

Diff $^{\circ}$ 2 $\frac{1}{2}$
 2 $\frac{1}{2}$
 2.5

700
 5) 1400
 280

$$x = m(\log b - \log \beta)$$

$$t \text{ temp } t' \frac{t+t'}{2}$$

$$m = 1 + \frac{t+t'-30}{2} 00244$$

Tables of heights

Europe

Mount Blanc } - 15.662
highest of the Alps

Monte Rosa not } 15.054
ascended, but Geom^y taken

Aiguille d'Argentiere 13.402

Glaciere de Buet. 10.124

Monteviso 9997

Monte Velino, on App^{ns} } 8397
covered with eternal snow

Peak of Beniffe — 11.889

Peak d'Assaro, one of }
the Pyrennees — } — 11.700.

American Mountains

Chimborazon — 20.801 or 19595

Cayamburro — 19.391

Antisana — 19.290

Pichincha. ————— 15670

City of Quito. the highest —
inhabited Place in the World. } 9377

British Mountains —

Snowden ————— 3555

Ben Lawers ————— 3950

Cairn Gorm ————— 4060

Ben Evis ————— 4278

Shiakhion ————— 3561

Ben Lomond ————— 3180.

Goutfel Island & Arran. 2950
remarkable for its beauty —

Arthur's Seat —

Edinburgh } 803

most of the measurements are
taken by means of a Portable
Barometer, to which is annexed
a Thermometer. it is usual to
have two Barometers, the one
at the top & the other at the bottom
of the Mountain. by this means
the measurement is more accu-
rate, which should also be per-
formed in calm dry weather

A Rough sketch is
here subjoined which
although badly done
gives a sufficient
idea of the instrument

The Thermometer being an instrument intimately connected with various experiments, both Chemical & Philosophical, it would be inconsistent with an elementary course, to pass over the general cause & effect of different changes of Temperature indicated by that useful instrument. The representation is the most common.

The mark 32 denotes Freezing point.

212° Water Boils

This scale is Fahrenheit.

Of Heat & its Mechanical Properties -

When we approach a fire we feel a sensation called heat. ~~On the~~ ~~the~~ ^{the} contrary when we approach Ice we feel a different sensation called Cold. - all Bodies are expanded by it - Heat may be produced in various ways 1st by compression, thus if air be compressed in a vessel & be afterwards allowed to escape it will absorb heat. Metal or Clay &c will produce heat when compressed -

Heat penetrates all bodies when placed near it, some bodies better than others Example
weight of Water. 143

weight of Ice 199 Temp. 40° Fahrenheit

$$x = \frac{AQ + A'Q'}{AQ + A'Q'}$$

$$x = \frac{Q + A'Q'}{Q + Q'}$$

$$x = 50 = \frac{143 + 190 + A \times 119 \times 3}{262}$$

$$A = -3.4$$

$$3.4 \times 32 = -112^{\circ} \text{ disappeared}$$

Heat is termed Caloric from the Greek. Kador. heat—

The sensation occasioned occasioned by the communication of Caloric to our Bodies is called

heating, of the sensation we
perceive by the scope of it is called
Cold. by a cold or hot body is measured
that a body is colder or hotter than
our own bodies so that when we touch
a body of the same temperature as our
we feel neither heat nor cold.

Besides the Thermometer which
cannot extend higher than 600°
(a Pyrometer (for measuring degrees
of heat from a red to the most
intense heat.) was invented by

Mr Wedgwood. the principle
of which depends on the contraction
of a piece of flint, after which
it is applied to a scale for that
purpose which measures the
Degrees.

Other instruments for measuring
the expansion of solids are called
Pyrometers of which Ramsden's
is the Best -

Table of expansions -

	Fahrenheit	
	By 1°	By 180°
Brass -	0.227	0.0194
Steel -	0.137	0.0084
Glass -	0.1	0.0083
Iron -	0.15	0.0125
Zinc -	0.37	0.03
Antimony -		0.19
Water -		0.478
Air -		{ 0.0215 0.0216

Heat may be produced in various
ways by Friction, hammering &c

as may also. Cold, by Snow
& Salt. by Snow & mixture of
Lime the most intense -

If more Caloric be com-
-municated to a body than it
can bear that body is converted
into a fluid. & on the contrary
when too much Caloric
is extracted from a body it be-
-comes a solid. The strongest
degree of heat that can be pro-
duced is by a Burning Lens
the intense heat ^{some} of which is
so very great as to overcome
every kind of body placed in
its focus. much could be said
on this subject such as

minor information however
is contrary to the present subject
were a brief explanation can
only be expected - to conclude
with the subject. Heat is that
universal mover of not only
the animal & Vegetable sys-
tem but seems as if concerned
in every thing existing in the
the World. Nature has made
ample provision for obviating
the effects of either increase or
decrease of temperature, thus
when the body is very warm
its perspiration is increased &
the vapour having its capacity
for Caloric increased. contri-

To cool the body —
Air Pump —

If 2 hemispheres be fitted
together & the air extracted

—ted

quiere

pounds

it will require
a force of 50
to separate them

The first experiment that presents itself is that of expansion.

Let a bladder containing a small portion of Air be placed under the Receiver of an Air Pump, upon exhausting the Air contained in the Receiver the Air in the Bladder will expand itself considerably, restore the Air to the Bladder will relapse.

Again Fig 2nd, a is a glass vessel containing Air, & a long tube upon exhausting the Air in the Receiver the elasticity of the Air in the Vessel will cause the Mercury to rise.

The next machine is the common Water Pump, for drawing water out of Wells. Springs &c. There are of 2 sorts the sucking & Forcing Pump

The common sucking pump acts by the production of a vacuum, when the piston

is raised the column of water fol-
lows. & by the mechanism of
the valve which opens on de-
pressing the Piston the column of
water in part gets above the
valve. the piston being then
raised the water above to the
level of the spout runs out
the height of the lower valve
should never exceed 32 Feet the im-
perfections liable to that kind
of work scarcely allow it to ex-
ceed 20 ft. The force required to
work a pump is as the height to
which the water is raised & as
the square of the Diameter of the

Pump - - The forcing pump raises the water above the valve the same as the sucking pump, but on depressing the piston, which has no valve the water is forced through the tube into the vessel which, by repeated strokes of the piston the air is condensed in it, producing a ^{continued} jet. by means of this pump, water may be raised to any height, with sufficient working power.

Several experiments of Mr. Smeaton followed this. ~~The~~ ~~condensers~~ ~~mills~~ they were however so rapidly gone over that the

most attention was insufficient to
commit them either to Memory or
Paper. confused as they are here
described some information may still
be gleaned, (on the subject)

Prop.

The force of wind that strikes on a sail
to turn the Mill, is as the product of the
cosine $\times$ by sq.th of sine of inclination
of the sail to the wind. Let AB = axis
 DC = one of Sails in dirⁿ. EC inclined to
 GC of the wind parallel to axis AB

$GC = \text{Radius}$

$GE = \text{sin}$

$EC = \text{cosine } \angle GCE$

∴ force of wind when this is of front
is to force of wind on the sail in
direction EC to it $\therefore GC^2 \therefore GE^2$

But GE is resolved into 2 forces, EF & GF

GF being parallel cannot turn it
round - -

but FE being perpendicular to it turns
the sail round.

Now $GE:EF::GE \frac{GE \times CE}{GC} \therefore GE^2 \therefore \frac{GE^2 \times CE}{GC}$

$\therefore GE^2 \therefore GE^2 \times EC = \text{cosine}$ in eq. of sine of the

angle $GCE = \text{Force that turns the Mill}$

when the Mill turns round with
the velocity from 20 to 29 miles ^{Hour}

The pressure is 34 pounds upon

the square Inch -

Brisk Wind from ^{miles miles} 30 to 35

	miles	miles per hour
Gale —————	40 to	45 —
Storm —————	60 —	70 —
Great Storm ———	70 —	90 —
Hurricane —————	100.	Prefer ^{red} 129 to 160

see second volume.

Of projectiles in Motion

These are by means of Bows; tubes blown through by the Indians in War the Arrow acquiring considerable velocity. Air Guns. & last of all those destructive Engines Fire arms the air gun consists in the rapid escape of condensed air from a Copper Ball filled with it. a valve in which being suddenly opened and shut allows

the escape of a portion of the con-
densed air, which produces
great effect on a Ball, this
last engine however is small
in its effect when compared with
the elastic vapour of Gunpow-
-der the invention of which
has produced such a revolu-
-tion in the system of warfare,
instead of the immense blood-
shed of Antient armies con-
-tending arm to arm, instead
of the thick Phalanx the long
Spear and short Dagger
of the Greeks or Romans

Enemies of the modern times annoy
each other at the Distance of
half a mile instead of the Ruins
constructed Ships of the Ancients
The floating buxwarks of the
Tide present on every side means
of annoyance - to whom the
world is indebted, it is uncertain
Roger Bacon was said to have mixed
together ingredients of Sulphur
Nitric & Charcoal, which upon
being heated in a covered Crucible
it was violently exploded - others
ascribe it as a German inven-
tion. This is also uncertain

In discharging a gun or piece of
artillery, great resistance is met
with from the air. Mr Robins cal-
culated that a shot from a 24
pounder, charged with 16 lbs of
Gun Powder if elevated at an an-
gle of 45° will range its shot
upon a plane 20-250. It is not a body

the range in theory. the shot is
estimated meets with a Resistance
= 400 lbs. hence the path of a
Shot differs greatly from the
Parabola, the resistance of the
air depends much on the gravity
of the air the shape of the shot
&c. &c. according to the velocity
with which it is impelled
when the velocity is small the
resistance of the air is trifling
when it is great the resistance
is prodigious. Mr Robins found
very little ^{advantage} ~~velocity~~ was gained
by projecting the Ball above
1200. In the second with greater

the variation from the Parabolic curve
is very great. a Gun to carry far should
not be charged with more ^{powder} than is about one
sixth of the weight of the shot, when the object
is near the Powder should be one third
of the weight of the shot - -

Several ways measuring the strength
of Gun powder by means of the Bar-
lotic Pendulum.

next an Instrument $v = 16$
of French Invention $100 = P + B$
which acts by means $h = 4$
of a small quantity $C \times B = (P + B) / 16$
of Powder acting on $C = \frac{P + B}{B} \times 16 = 1600$.

The spring which
pushes a cork along a wire the degrees
are pointed out on the arch below.

I will show the expansion of
Gun Powder

$$CB:BD::EK:KD$$

$$KD = \frac{BD \times EK}{BC}$$

$$KD = \frac{BD \times EK}{AB \times BB}$$

$BD, FE, DG, NC =$ velocity
in diff times

$$AB = a$$

$$BC = t$$

$$BD \text{ Int vel } \gamma = c$$

$$OP = \frac{ac}{a+t}$$

$$t \times v$$

$$ac \times \log \frac{a}{a+t}$$

$$S = ac \times \log \frac{a}{a+t}$$

$$y = g r^2$$

General Santoni in the service
of his Saracenic Majesty discovered
a practical method of finding the Para-
bolic curve - see next Vol.

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